LISTING OF CLAIMS

1. (Withdrawn). A method for determining a dynamical property of the systemic or pulmonary arterial tree comprising steps of:

   (a) measuring a physiologic signal over a plurality of cardiac cycles;

   (b) obtaining a relationship between the timing of a cardiac contraction and the evolution of the physiologic signal over a time period greater than that of a single cardiac cycle by analyzing the physiologic signal over a plurality of cardiac cycles; and

   (c) using the relationship to determine the dynamical property.

2. (Withdrawn). The method of claim 1, wherein the physiologic signal is invasively or noninvasively measured at any site in the systemic or pulmonary arterial tree.

3. (Withdrawn). The method of claim 1, wherein the physiologic signal is an arterial blood pressure (ABP) signal.

4. (Withdrawn). The method of claim 1, wherein the physiologic signal is a signal related to the arterial blood pressure signal.

5. (Withdrawn). The method of claim 1, wherein the physiologic signal is an arterial - systemic filling pressure difference (ASFPD) signal.

6. (Withdrawn). The method of claim 1, further comprising the measurement of the surface electrocardiogram (ECG).

7. (Withdrawn). The method of claim 6, further comprising analysis of the ECG.

8. (Withdrawn). The method of claim 1, further comprising using the dynamical property to determine one or more parameters of the cardiovascular system.

9. (Withdrawn). The method of claim 8, wherein the parameter is cardiac output or total peripheral resistance.

10. (Withdrawn). The method of claim 9, wherein the dynamical property is used in conjunction with a physiological signal to determine the cardiac output or total peripheral resistance.

11. (Withdrawn). The method of claim 10, wherein the physiologic signal, cardiac output, or total peripheral resistance are subjected to low pass filtering, single beat averaging, or multibeat averaging.

12. (Withdrawn). The method of claim 10, wherein the physiologic signal is arterial blood pressure, a signal related to arterial blood pressure, or the arterial-systemic filling pressure difference.

13. (Withdrawn). The method of claim 1, further comprising representing cardiac contractions by a train of impulses, each of which is located at the times of a cardiac contraction and has an area equal to the ensuing arterial pulse pressure.

14. (Withdrawn). The method of claim 1, further comprising representing cardiac contractions by a train of impulses, each of which is located at the times of a cardiac contraction, wherein the impulses have equal area.

15. (Withdrawn). The method of claim 1, further comprising determining the timing of cardiac contractions from the physiologic signal of step (a), an ECG signal or another physiologic signal.

16. (Withdrawn). The method of claim 1, further comprising filtering the physiologic signal, the cardiac contraction signal, or both prior to step (b).

17. (Withdrawn). The method of claim 1, further comprising estimating an impulse response representing the response of the physiologic signal to a single cardiac contraction.

18. (Withdrawn). The method of claim 1, wherein a parametric model is employed to impose causality.

19. (Withdrawn). The method of claim 18, wherein the parametric model is an auto-regressive moving average model.

20. (Withdrawn). The method of claim 18, further comprising estimating parameters of the model using a least squares method.

21. (Withdrawn). The method of claim 1, wherein the dynamical property is the impulse response function of the systemic or pulmonary arterial tree.

22. (Withdrawn). The method of claim 1, wherein the dynamical property is a characteristic time of the systemic or pulmonary arterial tree.

23. (Withdrawn). The method of claim 22, wherein step (b) comprises estimating the impulse response function, and wherein the characteristic time is determined by fitting a function to a portion of the estimated impulse response function.

24. (Withdrawn). The method of claim 23, wherein the portion of the estimated impulse response function begins a selected amount of time following the maximum value of the estimated impulse response function.

25. (Withdrawn). The method of claim 24, wherein the selected amount of time is predetermined.

26. (Withdrawn). The method of claim 23, wherein the characteristic time is a time constant determined by fitting an exponential function to a portion of the estimated impulse response function.

27. (Withdrawn). The method of claim 22, further comprising the step of determining cardiac output.

28. (Withdrawn). The method of claim 27, wherein the cardiac output is determined to within a proportionality constant by dividing the magnitude of the physiologic signal by the characteristic time.

29. (Withdrawn). The method of claim 28 further comprising adjusting the proportionality constant to depend on either the heart rate or arterial blood pressure.

30. (Withdrawn). The method of claim 28, wherein the physiologic signal is an arterial blood pressure signal or an arterial-systemic filling pressure difference signal.

31. (Withdrawn). The method of claim 28, wherein the proportionality constant is compliance, further comprising the step of estimating or measuring arterial compliance.

32. (Withdrawn). The method of claim 22, further comprising the step of determining total peripheral resistance to within a proportionality constant.

33. (Withdrawn). The method of claim 32 further comprising adjusting the proportionality constant to depend on either the heart rate or arterial blood pressure.

34. (Withdrawn). The method of claim 32, wherein the physiologic signal is an arterial blood pressure signal or an arterial-systemic filling pressure difference signal.

35. (Withdrawn). The method of claim 22, further comprising measuring absolute cardiac output using an alternative method.

36. (Withdrawn). The method of claim 35, further comprising determining the proportionality constant from the measurement of absolute cardiac output.

37. (Withdrawn). The method of claim 36, further comprising using the proportionality constant to determine absolute cardiac output, absolute total peripheral resistance, or both.

38. (Withdrawn). The method of claim 22, further comprising displaying cardiac output and, optionally, one or more additional cardiovascular system parameters.

39. (Withdrawn). The method of claim 22, further comprising the step of triggering an alarm if cardiac output decreases beyond a predetermined value or proportion.

40. (Withdrawn). A method of determining cardiac output to within a constant scale factor comprising steps of:

   (a) measuring a physiologic signal over a plurality of cardiac contraction cycles;

   (b) estimating a function that represents the response of the physiologic signal to a cardiac contraction over a time period greater than that of a single cardiac cycle;

   (c) determining a characteristic time of the function;

   (d) determining cardiac output to within a constant scale factor by dividing the magnitude of the physiologic signal by the characteristic time obtained in step (c).

41. (Withdrawn). The method of claim 40, wherein the cardiac output or the first physiological signal are subjected to single beat averaging, multibeat averaging, or low pass filtering.

42. (Withdrawn). The method of claim 40, wherein the physiologic signal or signals are invasively or noninvasively measured at any site in the systemic or pulmonary arterial tree.

43. (Withdrawn). The method of claim 40, wherein the physiologic signal of step (a) is an arterial blood pressure (ABP) signal.

44. (Withdrawn). The method of claim 40, wherein the physiologic signal of step (a) is a signal related to the arterial blood pressure signal.

45. (Withdrawn). The method of claim 40, wherein the physiologic signal of step (a) is an arterial – systemic filling pressure difference (ASFPD) signal.

46. (Withdrawn). The method of claim 40, further comprising the measurement of the surface electrocardiogram (ECG).

47. (Withdrawn). The method of claim 46, further comprising analysis of the ECG.

48. (Withdrawn). The method of claim 40, further comprising representing cardiac contractions by a train of impulses, each of which is located at the times of a cardiac contraction and has an area equal to the ensuing arterial pulse pressure.

49. (Withdrawn). The method of claim 40, further comprising representing cardiac contractions by a train of impulses, each of which is located at the times of a cardiac contraction, wherein the impulses have equal area.

50. (Withdrawn). The method of claim 40, further comprising determining the timing of cardiac contractions from the physiologic signal of step (a), an ECG signal or another physiologic signal.

51. (Withdrawn). The method of claim 40, further comprising filtering the physiologic signal, the cardiac contraction signal, or both prior to step (b).

52. (Withdrawn). The method of claim 40, further comprising estimating an impulse response representing the response of the physiologic signal to a single cardiac contraction.

53. (Withdrawn). The method of claim 40, wherein a parametric model is employed to impose causality.

54. (Withdrawn). The method of claim 53, wherein the parametric model is an auto-regressive moving average model.

55. (Withdrawn). The method of claim 53, further comprising estimating parameters of the model using a least squares method.

56. (Withdrawn). The method of claim 40, wherein step (b) comprises estimating the impulse response function, and wherein the characteristic time is determined by fitting a function to a portion of the estimated impulse response function.

57. (Withdrawn). The method of claim 56, wherein the portion of the estimated impulse response function begins a selected amount of time following the maximum value of the estimated impulse response function.

58. (Withdrawn). The method of claim 57, wherein the selected amount of time is predetermined.

59. (Withdrawn). The method of claim 57, wherein the selected amount of time is at least 1.5 seconds.

60. (Withdrawn). The method of claim 59, wherein the selected amount of time is approximately 2 seconds.

61. (Withdrawn). The method of claim 56, wherein the characteristic time is a time constant determined by fitting an exponential function to a portion of the estimated impulse response function.

62. (Withdrawn). The method of claim 40, wherein the cardiac output is determined to within a proportionality constant by dividing the magnitude of the physiologic signal by the characteristic time.

63. (Withdrawn). The method of claim 40, wherein the physiologic signal is an arterial blood pressure signal or an arterial-systemic filling pressure difference signal.

64. (Withdrawn). The method of claim 40, wherein the proportionality constant is compliance, further comprising the step of estimating or measuring arterial compliance.

65. (Withdrawn). The method of claim 40, further comprising the step of determining total peripheral resistance to within a proportionality constant.

66. (Withdrawn). The method of claim 40, further comprising measuring absolute cardiac output using an alternative method.

67. (Withdrawn). The method of claim 66, further comprising determining the proportionality constant from the measurement of absolute cardiac output.

68. (Withdrawn). The method of claim 67, further comprising using the proportionality constant to determine absolute cardiac output, absolute total peripheral resistance, or both.

69. (Withdrawn). The method of claim 40, further comprising displaying cardiac output and, optionally, one or more additional cardiovascular system parameters.

70. (Withdrawn). The method of claim 40, further comprising the step of triggering an alarm if cardiac output decreases beyond a predetermined value or proportion.

71. (Withdrawn). A method of determining cardiac output to within a constant scale factor comprising steps of:

    (a) measuring a first physiologic signal over a plurality of cardiac contraction cycles;

    (b) measuring a second physiologic signal over a plurality of cardiac contraction cycles;

    (c) estimating a function that represents the response of the second physiologic signal to a cardiac contraction over a time period greater than that of a single cardiac cycle;

    (d) determining a characteristic time of the function; and

    (e) determining cardiac output to within a constant scale factor by dividing the magnitude of the first physiologic signal by the characteristic time obtained in step (d).

72. (Withdrawn). The method of claim 71, wherein the cardiac output or the first physiological signal are subjected to single beat averaging, multibeat averaging, or low pass filtering.

73. (Withdrawn). A method of determining total peripheral resistance to within a constant scale factor comprising steps of:

    (a) measuring a physiologic signal over a plurality of cardiac contraction cycles;

(b) estimating a function that represents the response of the physiologic signal to a cardiac contraction over a time period greater than that of a single cardiac cycle; and

(c) determining a characteristic time of the function, wherein total peripheral resistance is given to within a constant factor by the characteristic time.

74. (Withdrawn). A method of determining cardiac output to within a constant scale factor comprising steps of:

(a) measuring an arterial blood pressure signal over a plurality of cardiac contraction cycles;

(b) estimating a function that represents the response of the arterial blood pressure signal to a cardiac contraction over a time period greater than that of a single cardiac cycle;

(c) fitting the function of step (b) to an exponential function over a time period that begins a selected amount of time following the maximum value of the function;

(d) estimating the time constant of the function of step (b) as the time constant of the exponential function of step (c); and

(e) determining cardiac output to within a constant scale factor by dividing arterial blood pressure by the time constant obtained in step (d).

75. (Withdrawn). The method of claim 74, wherein the selected amount of time is predetermined.

76. (Withdrawn). A method of determining total peripheral resistance to within a constant scale factor comprising steps of:

(a) measuring an arterial blood pressure signal over a plurality of cardiac contraction cycles;

(b) estimating a function that represents the response of the arterial blood pressure signal to a cardiac contraction over a time period greater than that of a single cardiac cycle;

(c) fitting the function of step (b) to an exponential function over a time period that begins a selected amount of time following the maximum value of the function;

(d) estimating the time constant of the function of step (b) as the time constant of the exponential function, wherein total peripheral resistance is given to within a constant factor by the time constant.

77. (Currently amended). An apparatus for determining a dynamical property of the systemic or pulmonary arterial tree comprising a computer system that includes:

(a) memory means which stores a program comprising computer-executable process steps; and

(b) a processor that executes the process steps so as to

(i) accept an input representing a measurement of a ~~physiologic~~ signal <u>indicative of cardiovascular system activity</u> over a plurality of cardiac cycles;

(ii) obtain a relationship between the timing of a cardiac contraction and the evolution of the ~~physiologic~~ signal over a time period greater than that of a single cardiac cycle by analyzing the ~~physiologic~~ signal over a plurality of cardiac cycles; and

(iii) use the relationship to determine the dynamical property.

78. (Original). The apparatus of claim 77, further comprising an analog-to-digital converter.

79. (Original). The apparatus of claim 77, wherein the apparatus includes a buffer system.

80. (Original). The apparatus of claim 77, wherein the apparatus includes a display device.

81. (Currently Amended). An apparatus for determining cardiac output to within a constant scale factor comprising a computer system that includes:

(a) memory means which stores a program comprising computer-executable process steps; and

(b) a processor that executes the process steps so as to:

(i) accept an input representing a measurement of ~~a physiologic signal~~ two signals indicative of cardiovascular system activity over a plurality of cardiac cycles;

~~(ii) estimate a function that represents the response of the physiologic signal to a cardiac contraction over a time period greater than that of a single cardiac cycle;~~

~~(iii)~~(ii) determine a characteristic time of the function ~~or of a second function~~ that represents the response of ~~a different physiologic signal~~ a second signal indicative of cardiovascular system activity to a cardiac contraction over a time period greater than a single cardiac cycle; and

~~(iv)~~(iii) determining cardiac output to within a constant scale factor by dividing the magnitude of the first ~~physiologic~~ signal indicative of cardiovascular system activity by the characteristic time obtained in step ~~(iii)~~ (ii).

82. (Original). The apparatus of claim 81, further comprising an analog-to-digital converter.

83. (Original). The apparatus of claim 81, wherein the apparatus includes a buffer system.

84. (Original). The apparatus of claim 81, wherein the apparatus includes a display device.

85. (Original) An apparatus for determining cardiac output to within a constant scale factor comprising a computer system that includes:

(a) memory means which stores a program comprising computer-executable process steps; and

(b) a processor that executes the process steps so as to:

(i) accept an input representing a measurement of an arterial blood pressure signal over a plurality of cardiac cycles;

(ii) estimate a function that represents the response of the arterial blood pressure to a single cardiac contraction;

(iii) fit the function of step (ii) to an exponential function over a time period that begins a selected amount of time following the maximum value of the function;

(iv) estimate the time constant of the function of step (ii) as the time constant of the exponential function of step (iii); and

(v) determine cardiac output to within a constant scale factor by dividing average ABP by the time constant obtained in step (iv).

86. (Original). The apparatus of claim 85, further comprising an analog-to-digital converter.

87. (Original). The apparatus of claim 85, wherein the apparatus includes a buffer system.

88. (Original). The apparatus of claim 85, wherein the apparatus includes a display device.

89. (New). An apparatus for determining a dynamical property of the systemic or pulmonary arterial tree comprising a computer system that includes:

(a) memory means which stores a program comprising computer-executable process steps; and

(b) a processor that executes the process steps so as to:

(i) accept an input representing a measurement of a signal indicative of cardiovascular system activity over a plurality of cardiac cycles;

(ii) capture the long time scale information by obtaining a relationship between the cardiac contractions and the signal; and

(iii) use the relationship to determine the dynamical property.

90. (New). The apparatus of claim 89 further comprising an analog-to-digital converter.

91. (New). The apparatus of claim 89 wherein the apparatus includes a buffer system.

92. (New). The apparatus of claim 89 wherein the apparatus includes a display device.

93. (New). An apparatus for determining cardiac output to within a scale factor comprising a computer system that includes:

(a) memory means which stores a program comprising computer-executable process steps; and

(b) a processor that executes the process steps so as to:

(i) accept an input representing a measurement of a signal indicative of cardiovascular system activity over a plurality of cardiac cycles;

(ii) capture the long time scale information by estimating an impulse response, which when convolved with the cardiac contractions, fits the signal;

(iii) determine a characteristic time of the estimated impulse response that represents the response of a second signal indicative of cardiovascular system activity to a cardiac contraction over a time period greater than a single cardiac cycle; and

(iv) determine cardiac output to within a scale factor by dividing a measure of the average of the signal by the characteristic time obtained in step (iii).

94. (New). The apparatus of claim 93 further comprising an analog-to-digital converter.

95. (New). The apparatus of claim 93 wherein the apparatus includes a buffer system.

96. (New). The apparatus of claim 93 wherein the apparatus includes a display device.

97. (New). An apparatus for determining cardiac output to within a scale factor comprising a computer system that includes:

(a) memory means which stores a program comprising computer-executable process steps; and

(b) a processor that executes the process steps so as to:

(i) accept an input representing a measurement of an APB signal over a plurality of cardiac cycles;

(ii) capture the long time scale information by estimating an impulse response which when convolved with the cardiac contractions fits the APB signal;

(iii) obtain a time constant by fitting an exponential-like function to the estimated impulse response over a time period that begins a selected amount of time following its maximum value;

(iv) determine cardiac output to within a scale factor by dividing a measure of the average APB by the time constant.

98. (New). The apparatus of claim 97 further comprising an analog-to-digital converter.

99. (New). The apparatus of claim 97 wherein the apparatus includes a buffer system.

100. (New). The apparatus of claim 97 wherein the apparatus includes a display device.